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Engineering Note

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Subject: Final mapping of fibers on backplanes between left hand and right hand CFT boards using by-4 multiplexing and only anchoring in the 'H' layer.

Introductory Comments

This note shows the final agreed-upon variation in backplane pin multiplexing schemes, documented in notes a980813a,a980818a and a980818b. In a meeting held 8/24/98 between Fred Borcherding, Jamieson Olsen, Pat Sheahan and myself it was agreed that timing restrictions in the system resulted in insufficient setup and hold time for a by-six multiplexing scheme to work. This note provides the pinout for a backplane using the following features:

- H-layer anchoring,
- By-four time multiplexing
- Sharing of 2/3 of the preshower signals seen by each board to its "previous" neighbor, but of only one threshold level. Boards will measure all 32 preshower signals against dual thresholds but only be allowed to transmit data associated with one threshold level to the neighbor board for cluster matching purposes.

System Introduction

Each cassette in the CFT system has two boards, the *left-hand board* (LHB) and the *right-hand board* (RHB). Each board 'sees' one sector of fibers in the detector. In order to provide mapping of tracks across sector boundaries, the LHB and the RHB have to share data with each other, and also with their neighbors on either side. The terms 'previous' and 'next' are used to indicate these neighbor boards.

Within a left/right pair, the LHB is the 'previous' board to the RHB, which makes the RHB the 'next' board to the LHB. Within a backplane, the LHB of the adjacent left/right pair is the 'next' board to the RHB of the current left/right pair. This is shown graphically in Figure 1. The adjacent backplane may not be located in the physically adjacent crate; adjacency of backplanes is determined by the cables which interconnect them.

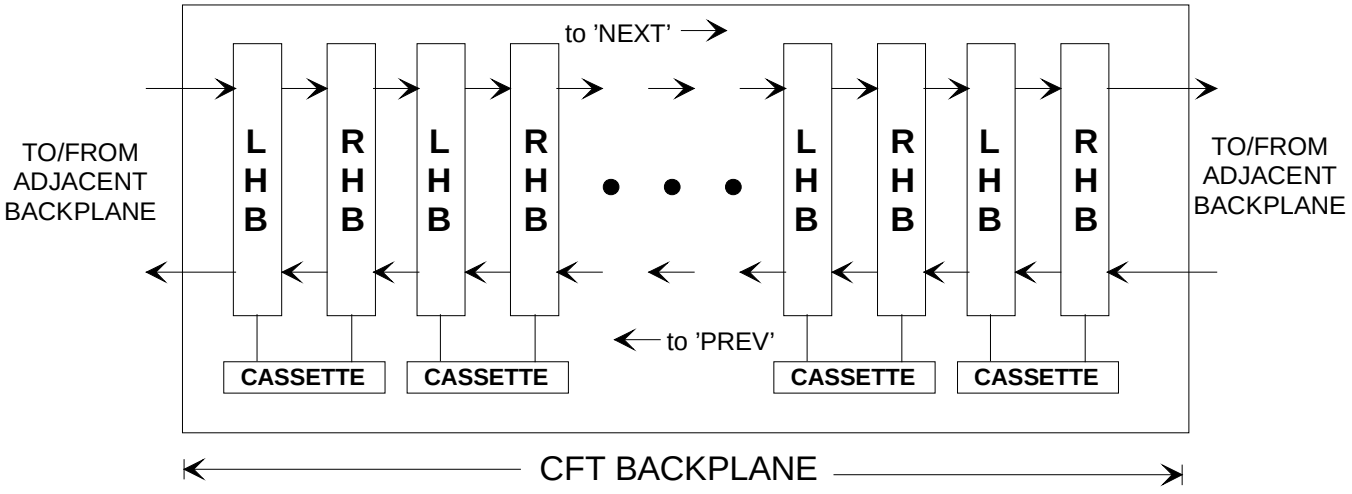

Figure 1

In the CFT documentation so far, fibers are listed as being on ‘inner’ or ‘outer’ singlet layers, and each sector is numbered individually. This causes problems when thinking about the backplanes because it causes duplicate signal names within a LHB/RHB pair; for instance, both boards within a pair are connected to a Ai[0] fiber. To eliminate duplicitous signal names, an arbitrary fiber number is assigned for each fiber in a *pair* of sectors. This allows for signal names to be unique within a pair of boards. A picture of a sector pair with all fibers numbered is shown in Figure 2.

A heavy black line shows the breakout of connections from the sector pair into the board pair. Fibers to the left of the heavy black line are physically connected to the LHB, and fibers to the right are connected to the RHB. Each layer of the detector (A-H) is assigned numbers from 0 on up across the pair of sectors associated with a left/right pair of boards. This allows each cassette to be viewed independently of any other cassette and independent of detector angle. A left/right board pair receives all the fibers of a sector pair and transfers them to the logically previous and next boards in the detector. In order to save pins, a set of fibers are transferred on each of four clock ticks within the 132 nsec cycle. Including latching of the outputs from the SIFT chips, five clock cycles are used to transfer all fibers between all boards.

The actual number of fibers which are shared on each layer is a function of the momentum resolution desired within the detector and the angle subtended by a fiber at the different radii of the different layers. Manuel Martin has previously issued a D0 Note describing this calculation. Figure 2 shows, using dashed lines, a graphical display of how many fibers of each sector are ‘seen’ by the neighboring boards. For those with color printers, the small circles are color-coded to indicate which fibers are physically routed to one board that actually ‘belong’ to the other board within a pair. Using the H layer as the anchor layer requires a minimal number of fibers be shared at the anchor point, just enough to insure a track doesn’t fall in the crack between sectors. As the search for tracks goes down towards the A layer, progressively more of the adjacent sector must be scanned to insure all of the track is seen.

The remainder of this document details which fibers are transferred on which clock tick, and how many pins of the backplane connection are required to accomplish the transfer. At the end of this document a pinout for the LHB and RHB connectors using 2 mm Hard Metric components is given.

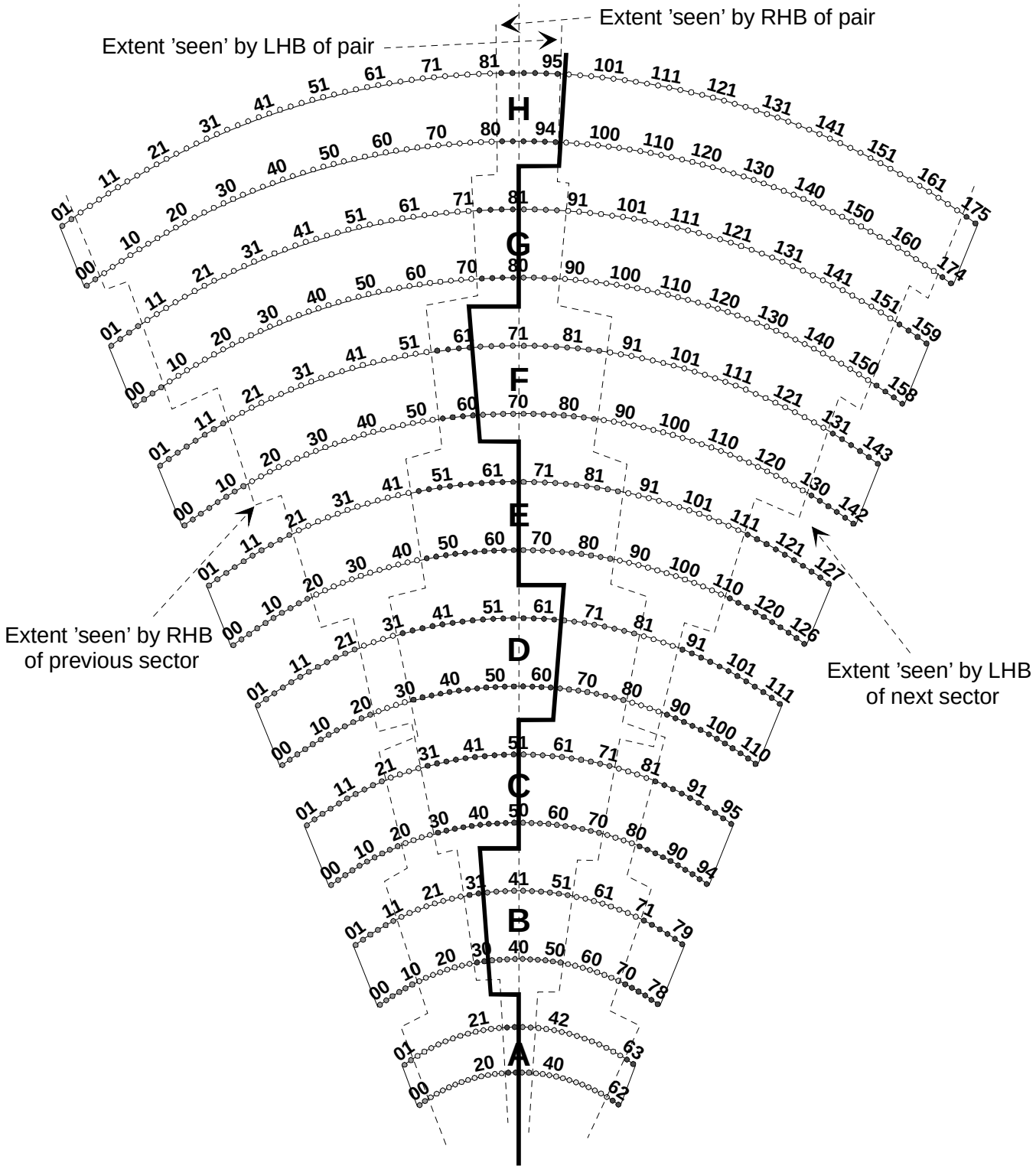
Extent 'seen' by RHB of pair
Extent 'seen' by LHB of pair
H
G
F
E
D
C
B
A
Extent 'seen' by RHB of previous sector
Extent 'seen' by LHB of next sector

Figure 2

A Layer

There are 32 fibers presented to each board from the A layer. On the first clock tick all the discriminator outputs from the SIFTs on both boards are captured in Latch logic. On the six successive clock ticks the fibers are transmitted between boards. The clock used throughout is the 53 MHz main clock.

- The LHB of a pair receives fibers A0-A31. Of these, fibers A0-A3 are sent to the previous neighbor, fibers A28-31 are sent to the RHB, and fibers A4-A27 are sent to both.
- The RHB of a pair receives fibers A32- A63. Fibers A32-A35 are sent to the LHB, fibers A60-A63 to the next neighbor and fibers A36-A59 are sent to both.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to RHB in previous sector	Latch data	A0	A1	A2	A3	1 out on LHB of pair 1 in on RHB in previous sector
LHB sends to RHB in previous sector and RHB of pair	Latch data	A4,A5,A6, A7 A8,A9	A10,A11, A12,A13, A14,A15	A16,A17, A18,A19, A20,A21	A22,A23, A24,A25, A26,A27	6 out on LHB of pair 6 in on RHB of previous sector 6 in on RHB of pair
LHB sends to RHB of pair	Latch data	A28	A29	A30	A31	1 out on LHB of pair 1 in on RHB of pair
RHB sends to LHB of pair	Latch data	A32	A33	A34	A35	1 out on RHB of pair 1 in on LHB of pair
RHB sends to LHB of pair and LHB in next sector	Latch data	A36,A37, A38,A39, A40,A41	A42,A43, A44,A45, A46,A47	A48,A49, A50,A51, A52,A53	A54,A55, A56,A57, A58,A59	6 out on RHB of pair 6 in on LHB of pair 6 in on LHB of next sector
RHB sends to LHB in next sector	Latch data	A60	A61	A62	A63	1 out on RHB of pair 1 in on LHB of next sector
						Total: Any LHB: 8 outputs, 14 inputs Any RHB: 8 outputs, 14 inputs

Table 1

Since the A layer is routed equally between boards, the number of I/O pins on the LHB and RHB are identical.

B Layer

The B layer is a little more complicated than the A layer. Not only are there more fibers, but they aren't evenly split between the LHB and the RHB. A few extra fibers enter the RHB and have to be transferred from the RHB to the LHB. This is caused by fiber bundling and connector pinout limitations. These fibers can be viewed as part of the previous/next data passing but are counted out separately to insure correct pin counts.

- The LHB directly receives fibers B0-B31. Fibers B0-B11 are sent to the previous neighbor, fibers B28-B31 are sent to the RHB, and fibers B12-B27 are sent to both.
- The RHB receives fibers B32-B79. Fibers B32-B39 are sent to the LHB to make up for the bundling mismatches. In addition, fibers B40-B51 are sent to the LHB. Fibers B68-B79 are sent to the next neighbor and fibers B52-B67 to both.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to previous neighbor	Latch data	B0,B1,B2	B3,B4,B5	B6,B7,B8	B9,B10,B11	3 out on LHB of pair 3 in on RHB of previous sector
LHB sends to both previous neighbor and RHB	Latch data	B12,B13, B14,B15	B16,B17, B18,B19	B20,B21, B22,B23	B24,B25, B26,B27	4 out on LHB of pair 4 in on RHB of previous sector 4 in on RHB of pair
LHB sends to RHB	Latch data	B28	B29	B30	B31	1 out on LHB of pair 1 in on RHB of pair
RHB sends to LHB, including bundle mismatch	Latch data	B32,B33, B34,B35, B36	B37,B38, B39,B40, B41	B42,B43, B44,B45, B46	B47,B48, B49,B50, B51	5 out on RHB of pair 5 in on LHB of pair
RHB sends to both LHB and next neighbor	Latch data	B52,B53, B54,B55	B56,B57, B58,B59	B60,B61, B62,B63	B64,B65, B66, B67	4 out on RHB of pair 4 in on LHB of pair 4 in on LHB of next sector
RHB sends to next neighbor	Latch data	B68,B69, B70	B71,B72, B73	B74,B75, B76	B77,B78, B79	3 out on RHB of pair 3 in on LHB of next sector
						Totals: LHB: 16 in, 8 out RHB: 12 in, 12 out

Table 2

Because of the mismatch in the number of fibers presented to the RHB and LHB, the number of inputs vs. outputs is different between the two board types. However, the total amount of I/O is the same for the two board types.

C layer

The C layer, like the A layer, is evenly split between the two boards in a left/right pair.

- The LHB receives fibers C0-C47. It sends fibers C0-C19 to the previous neighbor, fibers C28-C47 to the RHB, and fibers C20-C27 to both.
- The RHB receives fibers C48-C95. It sends fibers C48-C67 to the LHB, fibers C76-C95 to the next neighbor and fibers C68-C75 to both.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to RHB in previous sector	Latch data	C0,C1, C2,C3,C4	C5,C6,C7, C8,C9	C10,C11, C12,C13, C14	C15,C16, C17,C18, C19	5 out on LHB of pair 5 in on RHB of previous sector
LHB sends to both RHB in previous sector and RHB of pair	Latch data	C20,C21	C22,C23	C24,C25	C26,C27	2 out on LHB of pair 2 in on RHB of pair 2 in on RHB of previous sector
LHB sends to RHB of pair	Latch data	C28,C29, C30,C31, C32	C33,C34, C35,C36, C37	C38,C39, C40,C41, C42	C43,C44, C45,C46, C47	5 out on LHB of pair 5 in on RHB of pair
RHB sends to LHB of pair	Latch data	C48,C49, C50,C51, C52	C53,C54, C55,C56, C57	C58,C59, C60,C61, C62	C63,C64, C65,C66, C67	5 out on RHB of pair 5 in on LHB of pair
RHB sends to both LHB of pair and LHB in next sector	Latch data	C68,C69	C70,C71	C72, C73	C74,C75	2 out on RHB of pair 2 in on LHB of pair 2 in on LHB of next sector
RHB sends to LHB in next sector	Latch data	C76,C77, C78,C79, C80	C81,C82, C83,C64, C85	C86,C87, C88,C89, C90	C91,C92, C93,C94, C95	5 out on RHB of pair 5 in on LHB of next sector
						Totals: LHB: 14 inputs, 12 outputs. RHB: 14 inputs, 12 outputs.

Table 3

Again, an evenly split sector pair results in matching I/O counts for the two board types.

D layer

In the D layer, as in the B layer, eight fibers received by one board are passed to the other board in the left/right pair. The D layer passing requires that the LHB pass eight fibers (D56-D63) to the RHB. The fiber passing for previous/next architecture is as follows:

- The LHB receives fibers D00-D63 and sends fibers D00-D23 to the previous neighbor and fibers D32-D63 to the RHB. No fibers go to both.
- The RHB directly receives fibers D64-D111. Fibers D64-D79 are sent to the LHB, and fibers D88-D111 are sent to the next neighbor. No fibers go to both.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to RHB in previous sector	Latch data	D0,D1,D2, D3,D4,D5	D6,D7,D8, D9,D10,D11	D12,D13, D14,D15, D16,D17	D18,D19, D20,D21, D22,D23	6 out on LHB of pair 6 in on RHB of previous sector
LHB sends to RHB of pair, including bundle mismatch	Latch data	D32,D33, D34,D35, D36,D37, D38,D39	D40,D41, D42,D43, D44,D45, D46,D47	D48,D49, D50,D51, D52,D53, D54,D55	D56,D57, D58,D59, D60,D61, D62,D63,	8 out on LHB of pair 8 in on RHB of pair
RHB sends to LHB of pair	Latch data	D64,D65, D66,D67	D68,D69, D70,D71	D72,D73, D74,D75	D76,D77, D78,D79	4 out on RHB of pair 4 in on LHB of pair
RHB sends to LHB in next sector	Latch data	D88,D89, D90,D91, D92,D93	D94,D95, D96,D97, D98,D99	D100,D101, D102,D103, D104,D105	D106,D107, D108,D109, D110,D111	6 out on RHB of pair 6 in on LHB of next sector
						Totals: LHB: 14 outputs, 10 inputs RHB: 10 outputs, 14 inputs

Table 4

E layer

The E layer is symmetric like the A and C layers. 128 fibers are split evenly between the two boards in a left/right pair.

- The LHB receives fibers E00-E63. Fibers E00-E19 are sent to the previous neighbor, E44-E63 to the RHB, and none to both.
- The RHB receives fibers E64-E127. Fibers E64-E83 are sent to the LHB, E108-E127 to the next neighbor, and none to both.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to RHB in previous sector	Latch data	E00,E01, E02,E03, E04	E05,E06, E07,E08, E09	E10,E11, E12,E13, E14	E15,E16, E17,E18, E19	5 out on LHB 5 in on RHB of previous sector
LHB sends to RHB of pair	Latch data	E44,E45, E46,E47, E48	E49,E50, E51,E52, E53	E54,E55, E56,E57, E58	E59,E60, E61,E62, E63	5 out on LHB of pair 5 in on RHB of pair
RHB sends to LHB of pair	Latch data	E64,E65, E66,E67, E68	E69,E70, E71,E72, E73	E74,E75, E76,E77, E78	E79,E80, E81,E82, E83	5 out on RHB of pair 5 in on LHB of pair
RHB sends to LHB in next sector	Latch data	E108,E109, E110,E111, E112	E113,E114, E115,E116, E117	E118,E119, E120,E121, E122	E123,E124, E125,E126, E127	5 out on RHB of pair 5 in on LHB of next sector
						Totals: 10 inputs & 10 outputs (both board types)

Table 5

F layer

In the F layer, like the B layer, eight fibers are received by the RHB that really belong to the LHB.

- The LHB receives fibers F00-F63. Fibers F00-F15 are sent to the previous neighbor, fibers F56-F63 to the RHB, and none to both.
- The RHB receives fibers F64-F143. Fibers F64-F71 are sent via private bus to the LHB to compensate for bundling mismatches. Fibers F72-F87 are also sent to the LHB. Fibers F128-F143 are sent to the next neighbor, and none are sent to both.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to RHB of previous sector	Latch data	F00,F01, F02,F03	F04,F05, F06,F07	F08,F09, F10,F11	F12,F13, F14,F15	4 out on LHB of pair 4 in on RHB of previous sector
LHB sends to RHB of pair	Latch data	F56,F57	F58,F59	F60,F61	F62,F63	2 out on LHB of pair 2 in on RHB of pair
RHB sends to LHB of pair, including bundle mismatch	Latch data	F64,F65, F66,F67, F68,F69	F70,F71, F72,F73, F74,F75	F76,F77, F78,F79, F80,F81,	F82,F83, F84,F85, F86,F87	6 out on RHB of pair 6 in on LHB of pair
RHB sends to next neighbor	Latch data	F128,F129, F130,F131	F132,F133, F134,F135	F136,F137, F138,F139	F140,F141, F142,F143	4 out on RHB 4 in on LHB of next sector
						Totals: LHB: 10 inputs, 6 outputs. RHB: 6 inputs, 10 outputs.

Table 6

G layer

The G layer is again symmetric, with a total of 160 input fibers per board pair.

- The LHB receives fibers G00-G79. Fibers G00-G07 are sent to the previous neighbor; fibers G72-G79 to the RHB.
- The RHB receives fibers G80-G159. Fibers G80-G87 are sent to the LHB; fibers G152-G159 to the next neighbor.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to RHB in previous sector	Latch data	G00,G01	G02,G03	G04,G05	G06,G07	2 out on LHB of pair 2 in on RHB of previous sector
LHB sends to RHB	Latch data	G72,G73	G74,G75	G76,G77	G78,G79	2 out on LHB of pair 2 in on RHB of pair
RHB sends to LHB	Latch data	G80,G81	G82,G83	G84,G85	G86,G87	2 out on RHB of pair 2 in on LHB of pair
RHB sends to next neighbor	Latch data	G152,G153	G154,G155	G156,G157	G158,G159	2 out on RHB of pair 2 in on LHB of next sector
						Totals: 4 inputs & 4 outputs (both types)

Table 7

H layer

The outermost, or H layer, is asymmetric and contains a total of 176 fibers. Eight fibers are received by the LHB and sent via private bus to the RHB.

- The LHB receives fibers H00-H95. Fibers H00-H03 are sent to the previous neighbor. Fibers H84-H95 are sent to the RHB.
- The RHB directly receives fibers H96-H175. No fibers are sent to the LHB. Fibers H172-H175 are sent to the next neighbor.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to previous neighbor	Latch data	H00	H01	H02	H03	1 out on LHB of pair 1 in on RHB of previous sector
LHB sends to RHB, including bundle mismatch	Latch data	H84,H85, H86	H87,H88, H89	H90,H91, H92	H93,H94, H95	3 out on LHB of pair 3 in on RHB of pair
RHB sends to LHB in next sector	Latch data	H172	H173	H174	H175	1 out on RHB of pair 1 in on LHB of next sector
						Totals: LHB: 1 inputs, 4 outputs. RHB: 4 inputs, 1 outputs.

Table 8

Preshower signals

Each sector of the detector has 32 Preshower strips in addition to all the fibers. To further complicate the situation, each of the 32 Preshower strips seen by an LHB or RHB is sampled twice – against two different thresholds. Thus, 64 bits of preshower information is actually available. The current 'best guess' is that no more than 2/3 of the preshower strips (24 of them) need be shared with a neighbor board, and that only one threshold (so, only 22 bits) need be transmitted. Preshower cluster finding logic scans in one direction – from left to right – so preshower signals need only be shared with the board to the left (previous) of the current board. Table 9 shows the pin requirements for the LHB and the RHB, which are identical.

Since there is no cross-wiring of preshower signals between boards, there is no real need to number the preshower signals across a sector pair. However, to maintain uniformity, the convention is continued.

- The LHB receives preshower signals PS0-PS63 (32 strips, 2 thresholds per strip). Signals PS0-PS23 are sent to the previous neighbor, and none are sent to the RHB.
- The RHB receives preshower signals P64-P127 (32 strips, 2 thresholds per strip). Signals P64-P87 are sent to the LHB.

Clock Tick	1	2	3	4	5	Pins required on a given board
LHB sends to RHB in previous sector	Latch data	PS0,PS1, PS2,PS3, PS4,PS5	PS6,PS7, PS8,PS9, PS10,PS11	PS12,PS13, PS14,PS15, PS16,PS17	PS18,PS19, PS20,PS21, PS22,PS23	6 out on LHB of pair 6 in on RHB of previous sector
RHB sends to LHB of pair	Latch data	PS64,PS65, PS66,PS67, PS68,PS69	PS70,PS71, PS72,PS73, PS74,PS75	PS76,PS77, PS78,PS79, PS80,PS81	PS82,PS83, PS84,PS85, PS86,PS87	6 out on RHB of pair 6 in on LHB of pair
						Totals: 6 output and 6 input pins, both board types.

Table 9

Backplane Summation

Table 10 summarizes how many inputs and outputs each type of board – LHB and RHB – requires.

	LHB, multiplex by four		**RHB, multiplex by four**	
Layer	Inputs	Outputs	Inputs	Outputs
A	14	8	14	8
B	16	8	12	12
C	14	12	14	12
D	10	14	14	10
E	10	10	10	10
F	10	6	6	10
G	4	4	4	4
H	1	4	4	1
Preshower	6	6	6	6
TOTALS	85	72	84	73
GRAND TOTAL	157		157	

Table 10

Connector Pin Mapping

Metric connectors with a 2 mm pin pitch are used to provide the mechanical interconnect. Two connectors with a total of 220 I/O pins are used; this allows 63 pins for signal returns and bulk power distribution.

System Timing Details

Data transfer between any two boards is controlled by a set of data strobes. To compensate for the large board size (18.913 inches front to back), two timed strobes are used, one which is used for the front half of the board and one for the rear.